International Living With a Star

Active involvement of Germany

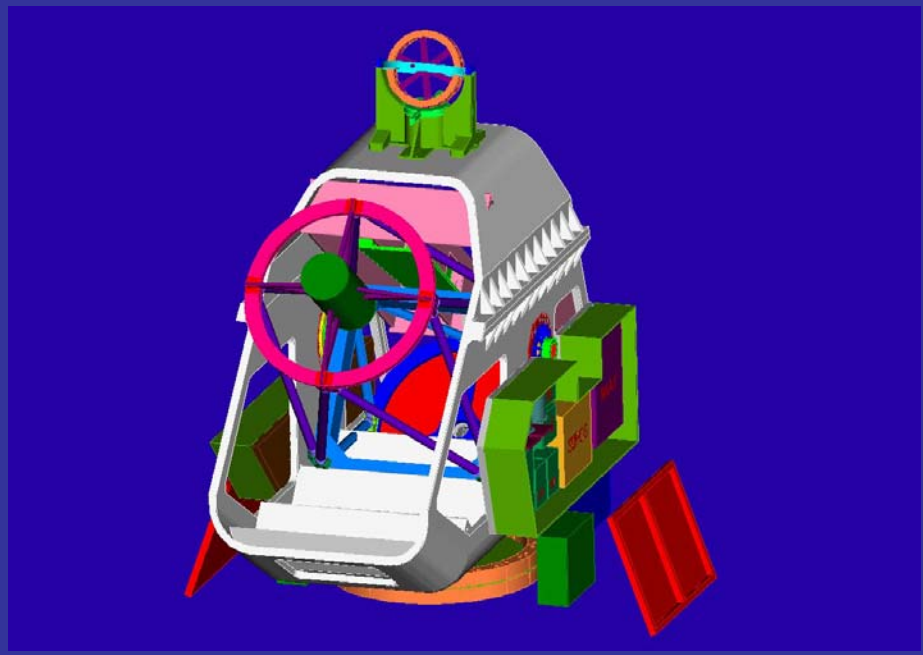
Status April 24, 2005

Presented by Rainer Schwenn, MPS Lindau,
On behalf of DLR Bonn, Wolfgang Frings

Main projects:

Sunrise
STEREO (Secchi, IMPACT, PLASTIC)
SolACES
Solar Orbiter

SUNRISE: High resolution UV/VIS observations of the Sun from the stratosphere



Max-Planck-Institut für Sonnensystemforschung
Katlenburg-Lindau, Germany

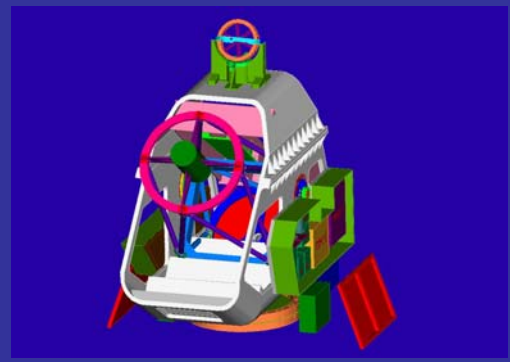
Sunrise: key questions

- How is the magnetic field brought to and removed from the solar surface? How does it develop there?
- What are the origin and the properties of the intermittent magnetic structure?
- How does the field provide/transport momentum and energy for the outer solar atmosphere?
- What is the underlying physics of the solar irradiance variability?
- What is the nature of the solar chromosphere?

Who is SUNRISE?

- S.K. Solanki, A. Gandorfer , P. Barthol, M. Schüssler, Max-Planck-Institut für Sonnensystemforschung, Katlenburg-Lindau, Germany
- B.W. Lites
  High Altitude Observatory, Boulder, USA
- V. Martinez-Pillet
  Instituto de Astrofisica de Canarias, Tenerife, Spain
- The IMaX team
  W. Schmidt
  Kiepenheuer Institut für Sonnenphysik, Freiburg, Germany
- A.M. Title
  Lockheed-Martin Solar and Astrophysics Laboratory, Palo Alto, USA

and the Sunrise team



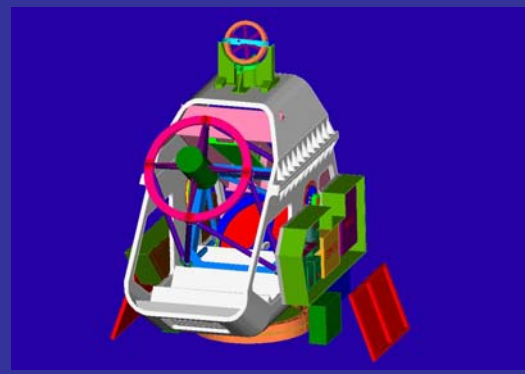
Sunrise: the overall concept

Sunrise

is a 1m balloon-borne optical solar telescope

has a set of post-focus instruments for the visible and UV

is planned to fly in a series of long duration balloon flights in Antarctica



in order to

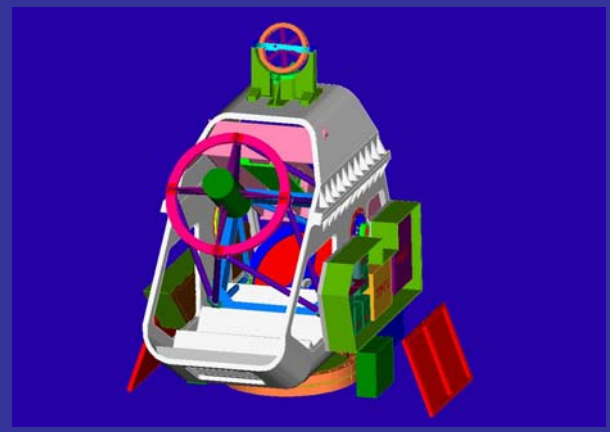
provide time series of spectra and diffraction limited images of the Sun

SUNRISE instrumentation

- **1m UV/VIS telescope**
- **Polarimetric Spectrograph: SUPoS**
  - Echelle type, reflective Littrow configuration
  - polarimetric (630nm) & diagnostic (279nm) branches
  - full Stokes vector (acc. $10^{-4)}$ in less than 5 s
- **Filtergraph: SUFi**
  - multi-wavelength phase diversity imager
  - 4 wavelength bands selected by filters (~1 nm)
- **Magnetograph: IMaX**
  - Fabry-Perot etalon & liquid crystal modulators
  - 2D maps of the full magnetic vector + Dopplergram

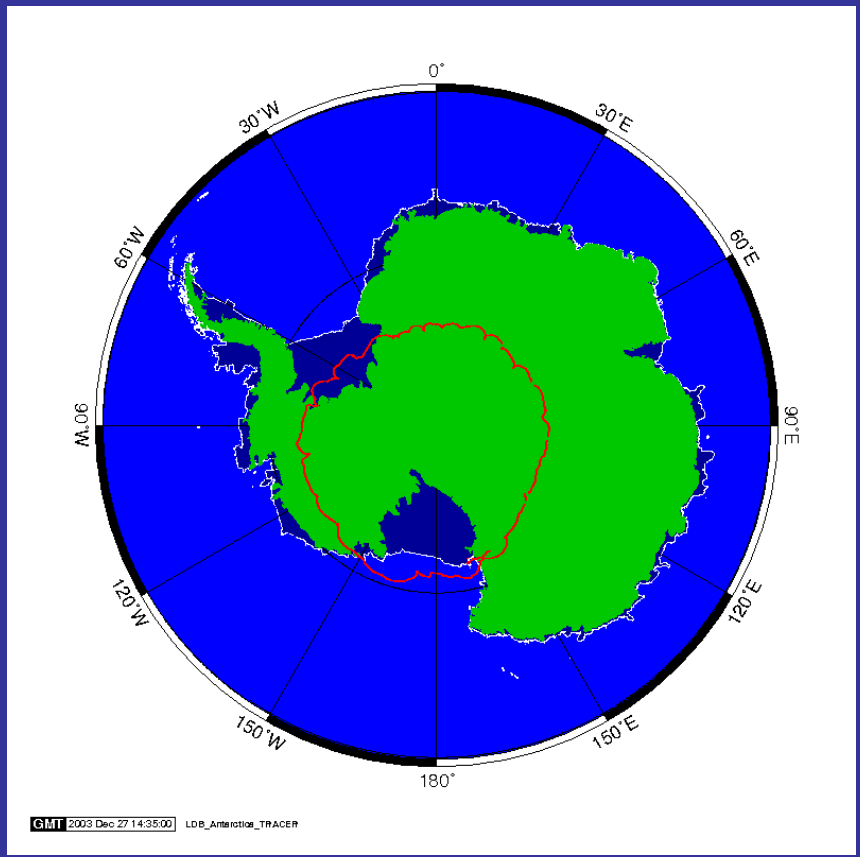
The SUNRISE telescope

- Lightweight telescope with 1m C/SiC lightweight mirror
- Built by Kayser-Threde in Munich
- Gregory configuration (f/25, elliptic secondary)
- alt-azimuth mount
- field of view: 3.4 arcmin (150 Mm on the Sun)
- M2: adjustable with 3 degrees of freedom, controlled by a wavefront sensor



Th Sunrise balloon concept

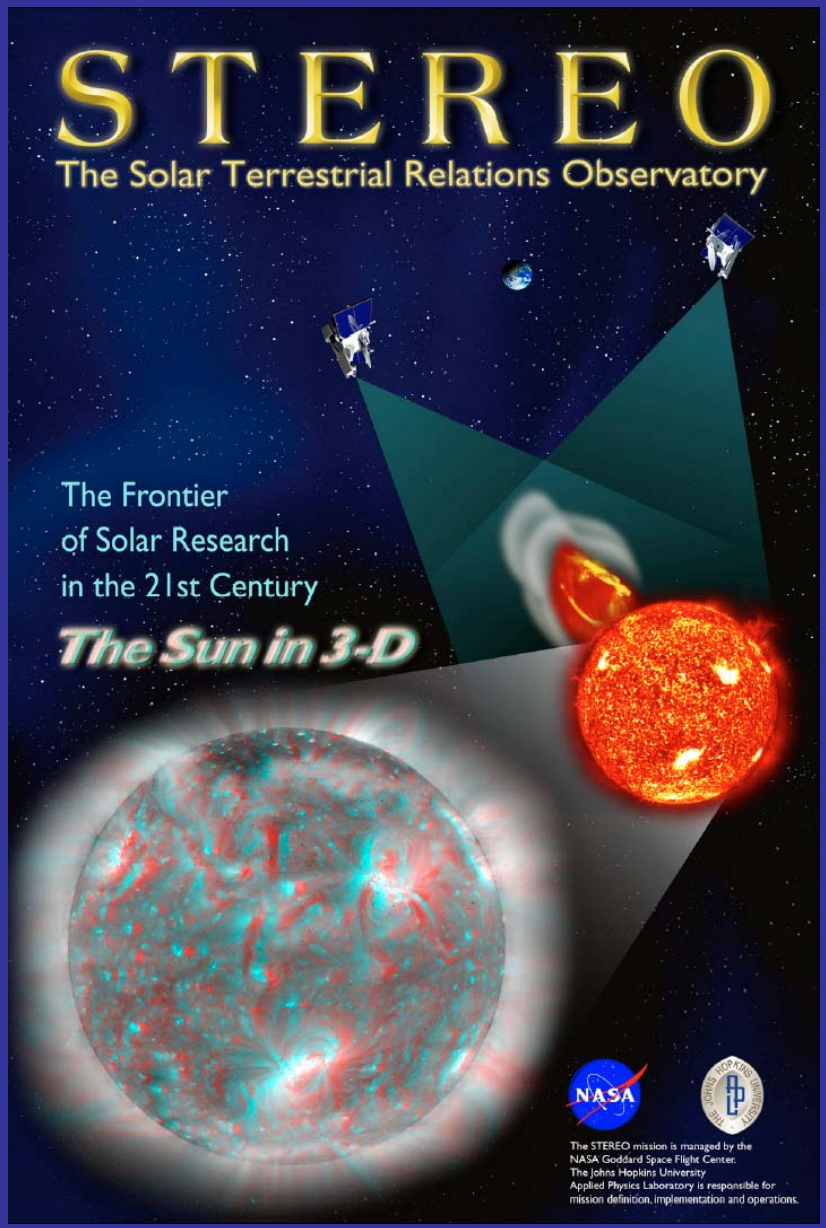
A long duration flight across Antarctica in summer



Flight concept and time schedule

- Phase A/B completed 3/2004
- German and Spanish contributions fully funded
- C/D phase started early this year
- Test flight of gondola 2005
- First science flight planned in 2008 in Antarctica within NASA's long duration balloon program

STEREO Mission



Solar Terrestrial Relations Observatory

Launch: February 2006

2 drifting spacecraft in heliosynchronous orbit

Drift rate: 22°/year

Defined by NASA SDT 1997

Scientific payload:

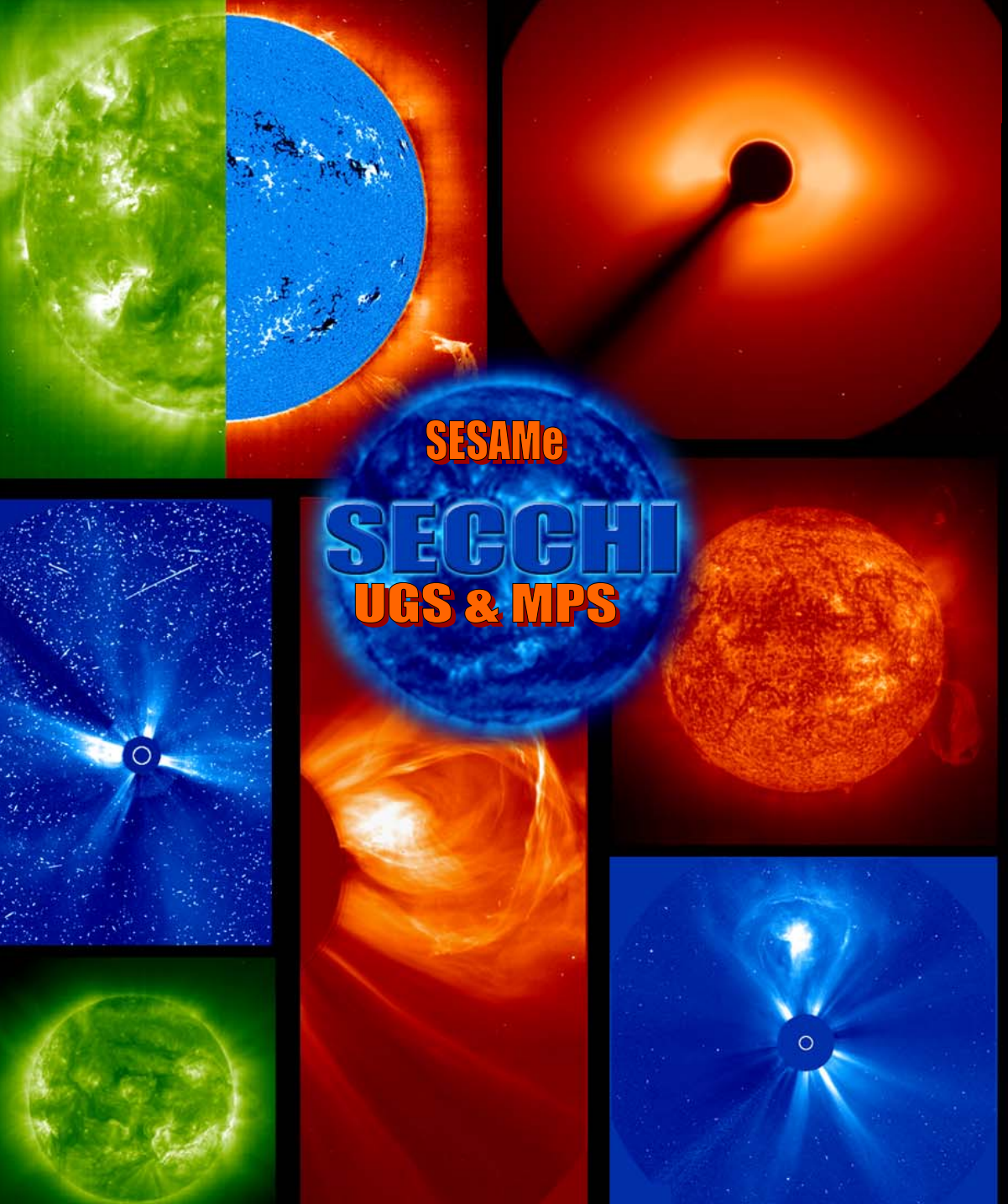
SECCHI *

IMPACT *

PLASTIC *

SWAVES

* with major German involvement

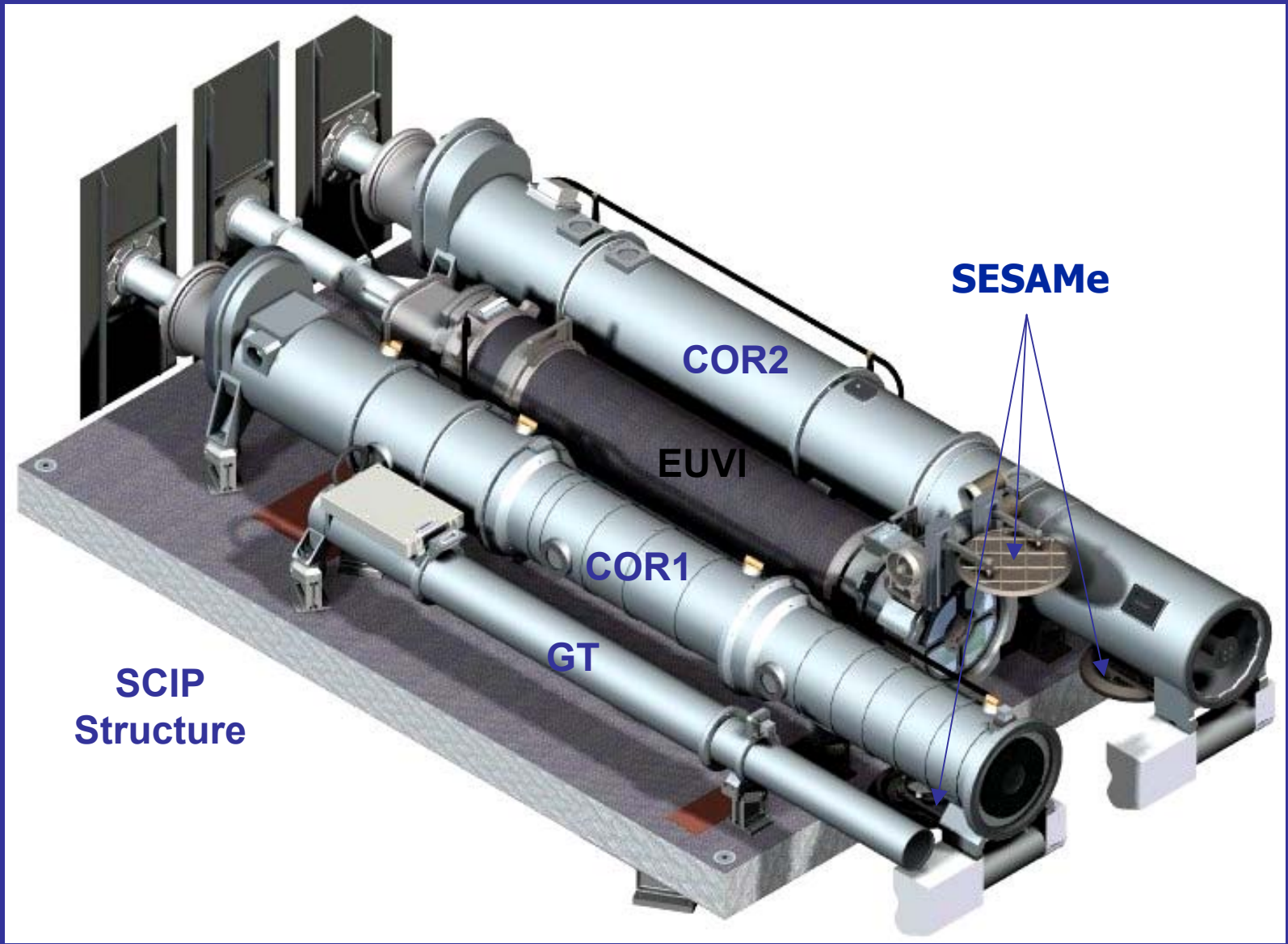


SECCHI

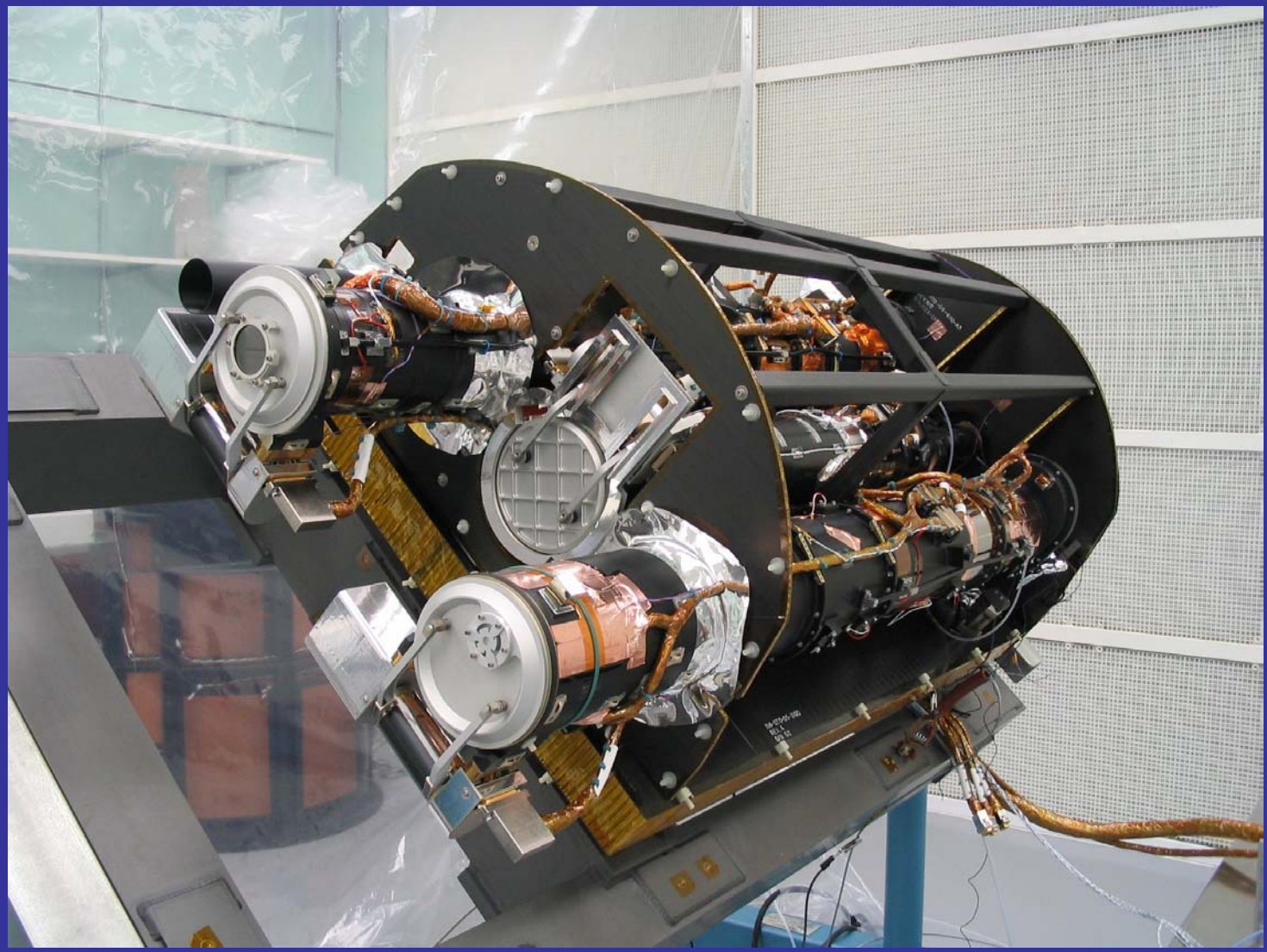
Sun Earth Connection
Coronal & Heliospheric
Investigation on STEREO

Cols at MPS Lindau

SECCHI/SCIP Design for STEREO



SECCHI-SCIP-B



SolACES – SOLar Auto-Calibrating EUV / UV Spectrophotometers

on the International Space Station

Fraunhofer Institute for Physical Measurement Techniques (IPM), Freiburg (Germany)
(PI: G. Schmidtke)

Fraunhofer Institut Physikalische Messtechnik

CoIs: Kiepenheuer Institute for Solar Physics, Freiburg (Germany)
Institute for Meteorology, University of Leipzig (Germany)
Astrophysical Institute Potsdam, AIP (Germany)
DLR / DFD, Neustrelitz (Germany)
Environment Technologies, Los Angeles, CA (USA)
Atmospheric and Space Physics (LASP), Boulder, CO (USA)
Science Center (SSC) of the University of Southern California, Los Angeles, CA (USA)
Service d'aeronomie, Verrières-le-Buisson (France)
Phys.-Meteorologisches Obs. Davos / World Radiation Center Davos (Switzerland)

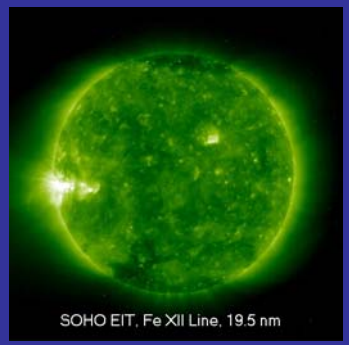
Funding: DLR, ESA, Fraunhofer Gesellschaft (FhG)

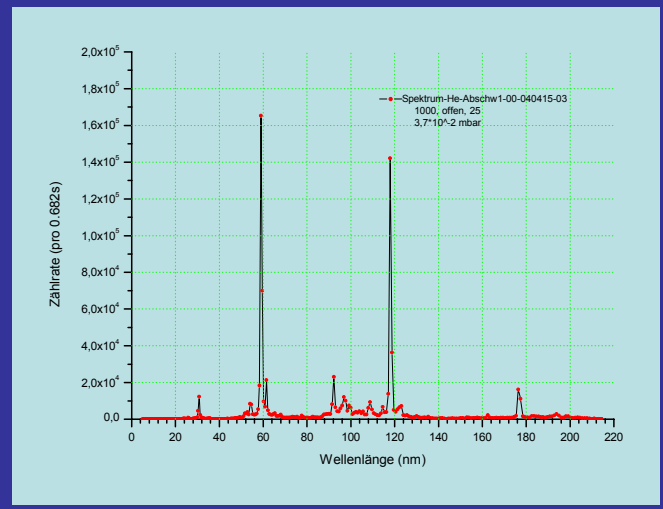
MPS

SolACES: Scientific Objectives & Applications

Fraunhofer IPM Institut Physikalische Messtechnik

Primary Goal:
(Quasi) continuous spectral monitoring (15 spectra per day) of UV / EUV radiation of the Sun in the wavelength range 17…220 nm with a high absolute radiometric accuracy (better than 10%)





Deduced Goals & Applications:

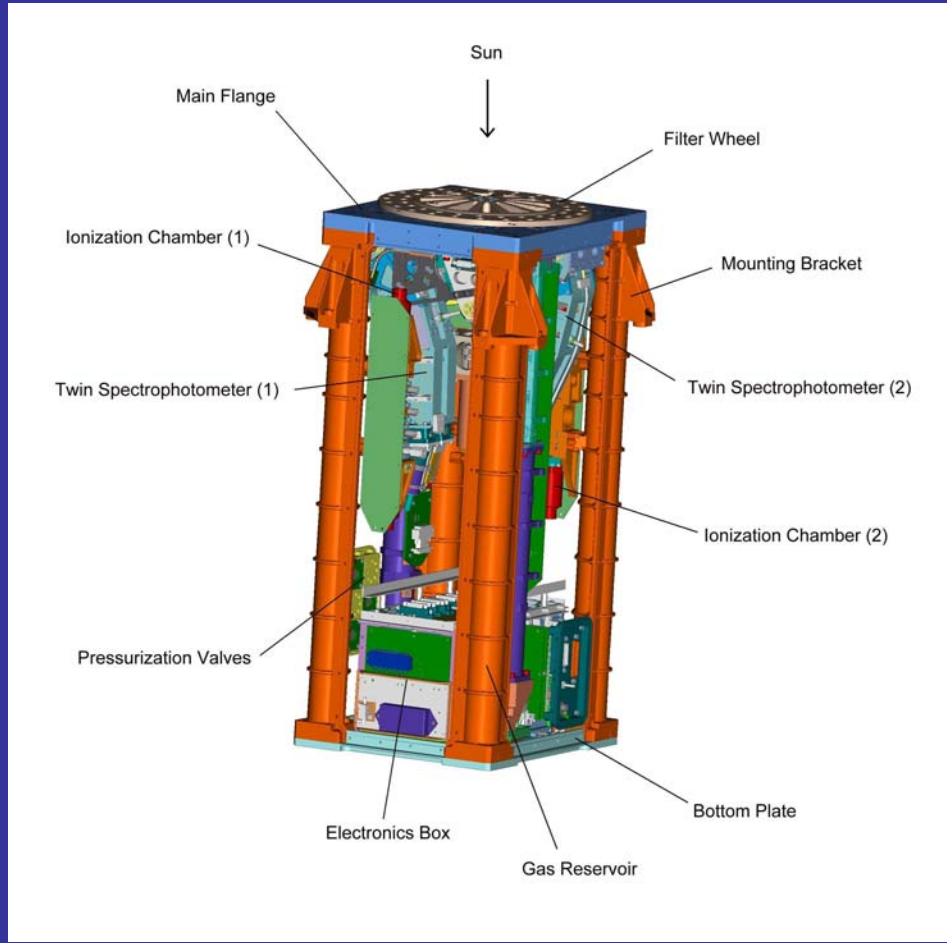
- Determination & modelling of the solar EUV / UV spectral irradiance
- Modelling of the terrestrial thermosphere & ionosphere (EUV / UV indices)
- Semi-empirical modelling of active regions on the Sun
- Investigation of solar-terrestrial relations & solar-stellar connections
- Aspects of space weather (impacts on satellite communication & navigation)
- EUV / UV space instrumentation & its calibration

MPS

SolACES: Instrument & Measurement Principle

Fraunhofer IPM Institut Physikalische Messtechnik

- Standard Spectroscopic Measurement
  - ⇨ two twin spectrophotometers with channel electron multipliers
- Auto-Calibration Procedure
  - ⇨ absolute EUV / UV fluxes by ionization chamber measurements with filters
  - ⇨ determination of instantaneous filter transmissions by spectrophotometric measurement with & without filters



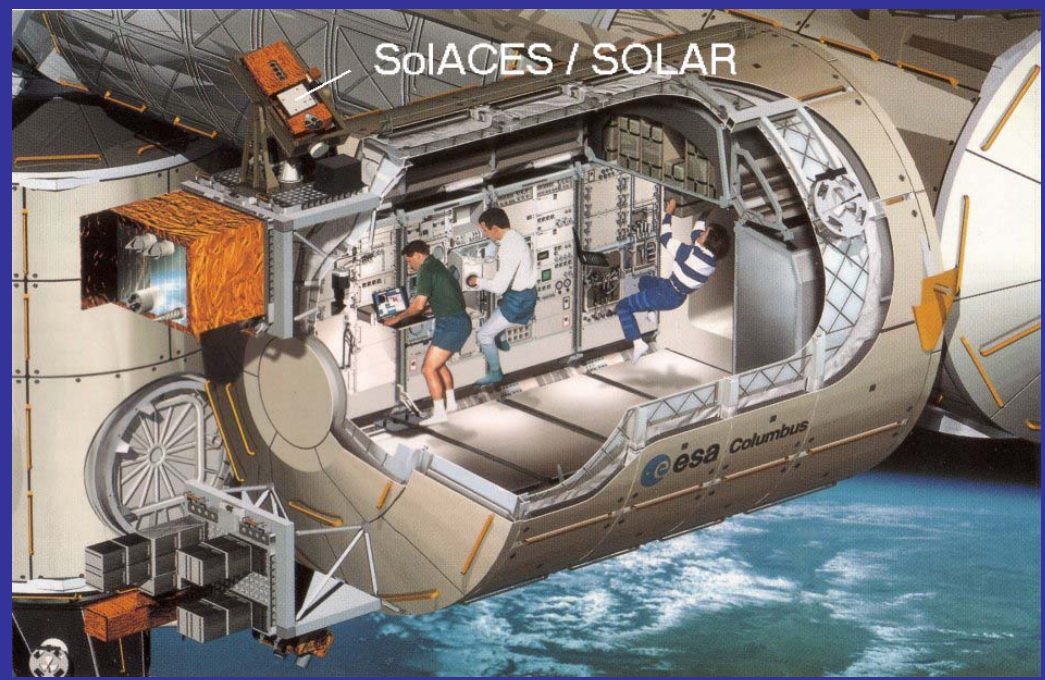
MPS

SolACES: Mission & Instrument Characteristics

Fraunhofer Institut Physikalische Messtechnik

- Start of operation / launch: 2007
- Launcher: Space Shuttle (NASA)
- Nominal / potential mission duration: 18 / 36 months
- Orbit characteristics: ISS orbit (altitude ~400 km)
- Observation schedule: max. 20 minutes per orbit

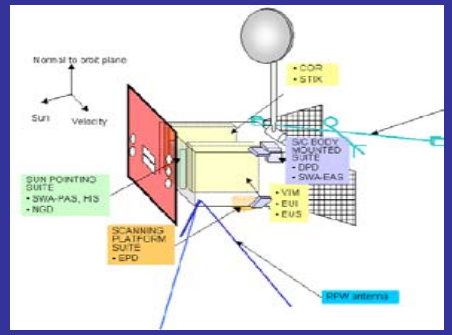
- Size: 25 x 29 x 60 cm3
- Electrical power 25 to 60 W
- Data rate: ~1.0 kbit/s
- Spectral range: 7…220 nm
- Spectral resolution: 0.5…2 nm
- Mass: 23.0 kg
  < 10% (goal: < 1…3%)



MPS

Solar Orbiter

and global strategy missions



ESA Solar Orbiter

NASA Solar Sentinels [2013]

NASA STEREO

ESA Solar Orbiter [2013]

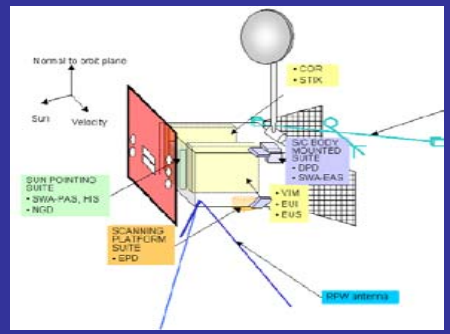
NASA STEREO [2006]

ISAS Solar-B [2006]

NASA Solar Dynamics Observatory [2008]

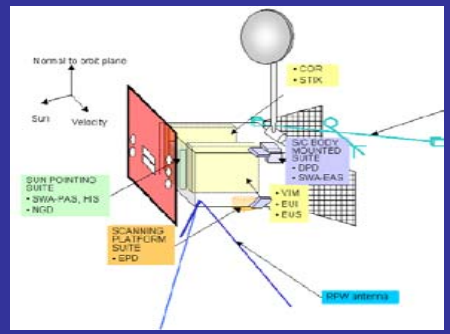
Solar Orbiter

- Launch date (current baseline): **Oct 2013** (backup opportunity in May 2015)
- Launch by Soyuz-Fregat 2-1b
- Cruise phase (1.8 yrs)
  - Solar Electric Propulsion (SEP)
  - Gravity Assist Manoeuvres (Venus, Earth)
- Science phase
  - 3:2 resonant orbit with Venus (period 149.8 days)
- Total SEP mission duration, incl. extended phase (2013): 7 yrs
- Minimum perihelion distance: 48 solar radii (0.22 AU)
- Maximum solar latitude: 35° (in extended phase)

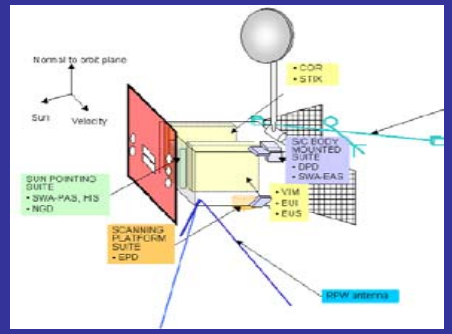


Solar Orbiter reference payload

Instrument	Acronym	Mass (kg)	Power (W)
In-Situ Instruments			
Solar Wind Plasma Analyzer	SWA	14.0	13
Radio and Plasma Wave Analyzer	RPW	9.6	6.4
Magnetometer	MAG	1.5	1.5
Energetic Particle Detector	EPD	5.7	8.5
Dust Particle Detector	DPD	1.8	6
Neutron/Gamma Detector	NGD	4.2	4
Common Elements (DPU,DC/DC..)		11.3	8
Remote-Sensing Instruments			
Visible Imager & Magnetograph	VIM	30.4	35
EUV Spectrometer	EUS	18.0	25
EUV Imager	EUI	20.4	25
Visible Coronagraph	COR	18.3	25
Spectrometer Telescope Imaging X-rays	STIX	4.4	4
Payload Support Elements (boom, rotating platform, doors, …)		27.6	20
TOTAL (incl. Margins)		167.2	181.4



Solar Orbiter



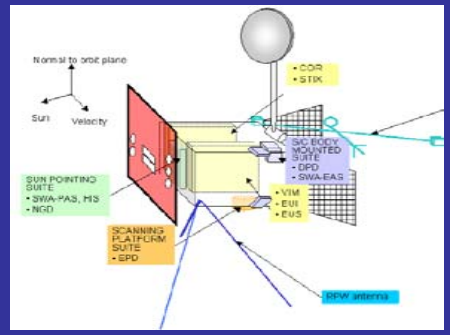
Instruments to be selected via a competetive process based on an AO open to the international scientific community

Philosophy:

- Resource-efficient instrumentation (e.g., remote-sensing instruments to be "1 metre, 1 arcsec resolution" class)
- Resource envelope as given in PDD
- Science Management Plan calls for proposals to be submitted via relevant funding agencies

- **ESA Solar Orbiter AO**:
  - Foreseen for release in mid-2006
  - Solar Orbiter AO to be coordinated with Sentinel AO

Solar Orbiter



Tentative sequence of events:

- Delta Studies in industry (Apr-Jul 2005) focusing on
  - I/F between heat shield and instruments
  - Chemical propulsion option
  - AO preparation
- Final Assessment Report to ESA executive by Q3/2005
- Start of critical Technology Development Activities: Sep 2005
- ESA internal evaluation Q4/2005
- ESA Science Programme Committee go-ahead for payload AO: Feb 2006
- Release of AO by end of Q2/2006
- Technical Assistance Phase (1 yr): Q1/2006 - Q1/2007
- Mission Definition Phase (1.5 yrs): Q2/2007 – Q3/2008
- Implementation Phase (5 yrs, incl. contingency): Q1/2009 – Q4/2013
- Launch: Oct 2013

Solar Orbiter firsts

- Explore the uncharted innermost regions of our solar system
- Study the Sun from close-up (48 R_s or 0.22 AU)
- Fly by the Sun and examine the solar surface and the space above from a nearly co-rotating vantage point
- Provide images of the Sun's polar regions from heliographic latitudes as high as (31°) 35°